Clinical Review

The Role of Percutaneous Lung Biopsy in the Workup of a Solitary Pulmonary Nodule

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As the technique of percutaneous lung biopsy continues to evolve, it offers an increasingly accurate method of establishing the malignancy or benignity of a solitary pulmonary nodule. There are relatively few contraindications to the procedure, and the complications—primarily pneumothorax and hemoptysis—generally resolve without therapy. Transthoracic needle aspiration has an important role in the workup for a "coin lesion." Other elements of the diagnostic workup—particularly the history, a chest roentgenogram, computed tomography, sputum cytology, and transbronchial brush biopsy—may either add to or substitute for a transthoracic needle aspiration biopsy. An algorithm can be used to guide the diagnostic approach to a solitary pulmonary nodule.

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In 1983, more than 113,000 Americans died of primary carcinoma of the lung.[1] Most died within a year of diagnosis.[2] Lung cancer has been the leading cause of cancer death among American men for many years, and, by the mid-1980s, the disease showed it had "come a long way, Baby," by vying with breast cancer as the number one cause of cancer death in women in the United States.[1]

Some 5% to 15% of lung cancers present asymptomatically, usually being detected on chest radiographs.[2] The most common radiologic finding in these cases is the solitary pulmonary nodule, defined by Siegelman and co-workers as "a single rounded or ovoid lesion in the lung parenchyma which is not associated with obvious adenopathy, atelectasis, or pneumonia."[3] The differential diagnosis of the solitary nodule is extensive (see Table 1). What proportion of solitary lung nodules is malignant depends greatly on the criteria used for inclusion in a series. Lesions detected in mass screening programs may have a malignancy rate of only 3%; resected nodules have as high as a 60% rate of malignancy.[3]

Therein lies the dilemma: among the many patients with a solitary pulmonary nodule noted on chest radiograph, who should undergo thoracotomy? Investigators have developed several preoperative evaluations of the solitary pulmonary mass, with varying specificities, sensitivities, and predictive values.

In this article I will review these methods of assessing a solitary pulmonary nodule, but my discussion will focus on transthoracic needle aspiration biopsy.

The justification for such a biopsy is to prevent an unnecessary operation. The 1984 study by Keagy and colleagues shows that lobectomy and pneumonectomy—as well as minor resections—are frequently done for benign disease.[4] Steele's classic series of resected pulmonary nodules aptly shows the attendant risk of such an operation: he reported two perioperative deaths among patients with benign disease.[5]

I will discuss the balance between the risks of percutaneous lung biopsy—that of a missed diagnosis as well as risks of the procedure itself—and the benefits of the technique. I will also put transthoracic needle aspiration biopsy into perspective in the overall workup of patients who have a solitary pulmonary nodule.

Percutaneous Lung Biopsy

History

The first transthoracic needle biopsy was done in 1883 by Leyden, who sought to obtain microbes from a patient with pneumonia.[6] In 1886, Menetrier was the first to diagnose lung cancer from a transthoracic biopsy.[7] In the 1930s and 1940s, the procedure fell out of favor: the complication rate was high, and several deaths had occurred following percutaneous biopsy.[8]

During the 1960s, however, Dahlgren and Nordenstrom reawakened interest in the transthoracic biopsy.[9] The technique was considerably safer with the introduction of improved image-intensified fluoroscopy and narrow-gauge, thin-walled needles. Moreover, cytologists had refined their techniques, making the results of a percutaneous lung biopsy more accurate. In the past two decades the procedure has become increasingly popular.

Technique

A full description of the method of percutaneous lung biopsy has been provided by Greene.[10] Only general trends will be discussed here.

Beginning in the 1960s, improvements in cytology allowed fine-needle aspiration to replace large-bore cutting histologic biopsies with their attendant complications.[10] Moreover, recently investigators have developed thin needles that yield histologic as well as cytologic specimens. Westcott advocates the use of a slotted 20-gauge needle,[11] and Greene and associates recently published promising results using fine needles with circumferentially bevelled tips.[12]

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Percutaneous lung biopsy is generally done with fluoroscopic guidance, but computed tomography (CT) can occasionally play a helpful role. CT guidance is vital if either a pulmonary lesion is not visualized on both posteroanterior and lateral chest radiographs or a mass cannot be easily distinguished from normal hilar or mediastinal structures by using only fluoroscopy.[13] Moreover, CT may complement the use of fluoroscopy in the evaluation of a large chest mass, where CT images can help the fluoroscopist avoid a nonviable, necrotic—and thus nondiagnostic—portion of the mass.[14]

Having a pathologist present at the biopsy will increase both the accuracy and the safety of the study. He or she can do a "wet read" of the specimen and immediately decide on its adequacy,[15] thus avoiding unnecessary, numerous attempts. If the pathologist is familiar with the clinical history, mistakes such as confusing the sequelae of irradiation or chemotherapy with a malignant neoplasm can also be avoided,[16] thus increasing the specificity of the procedure.

Contraindications

Relative and absolute contraindications to a transthoracic needle aspiration biopsy include a bleeding diathesis or anticoagulation therapy; a possibility of the mass being a vascular lesion or an echinococcal cyst; severe obstructive or restrictive lung disease; local bullous lung disease near the target; pulmonary hypertension; an uncooperative patient or one with an uncontrollable cough; a patient either on or likely to soon require positive-pressure mechanical ventilation; and a contralateral pneumonectomy.[8,12,17,18]

Complications

The most common complication of percutaneous lung biopsy is pneumothorax. The incidence of pneumothorax ranges from 10% to 49%, but the rate of cases requiring therapy is much lower, usually between 4% and 10%.[8,10-12,17-22] A chest tube or an aortography catheter may be placed for a progressive or significant pneumothorax.[11]

The risk of pneumothorax is increased in patients older than 50 years, in patients who move or cough, if there is emphysema, if fissures are crossed, if the mass is central, or if the mass is cavitary.[15,19]

TABLE 1.—*The Differential Diagnosis of the Solitary Pulmonary Nodule*

Malignant
Bronchogenic carcinoma
Epidermoid or squamous cell
Adenocarcinoma
Small-cell carcinoma
Large-cell carcinoma
Bronchial adenoma
Metastases
Other primary cancers
Benign
Granuloma—including nonspecific inflammation, tuberculosis, cryptococcosis, histoplasmosis, aspergillosis, and other infections
Hamartoma
Bronchogenic cyst
Chronic pneumonitis or abscess
Benign pleural tumor
Bronchopulmonary sequestration
Nodular pulmonary amyloidosis
Neurogenic nodule
Rheumatoid nodule
Lipoma
Other benign tumors

The second common complication of percutaneous lung biopsy is hemoptysis. The incidence of hemoptysis ranges from 8% to 19%,[8,11,17,19] and the problem is generally minor and self-limited. Hemoptysis is more common after biopsies of central lesions.[19]

Fatal complications of percutaneous lung biopsy are rare. Greene estimated the mortality since 1970 to be "considerably less than 0.02%."[10] The use of thin needles has probably been critical in reducing the mortality, for before the 1960s, the most common cause of death from percutaneous lung biopsy was hemorrhage. The safety of thin-needle biopsy is shown by Westcott's report of four patients with thoracic aortic aneurysms simulating pulmonary masses that, following the biopsy of these masses, showed no radiographic or clinical evidence of hemorrhage.[11]

Air embolism is another potentially fatal complication, but this is rare. As of 1982, only one case of fatal air embolism had ever been reported.[10,23] The danger in doing a transthoracic needle biopsy is that only 2 to 3 ml of air is required to cause death in patients with pulmonary venous embolism. In his discussion, Westcott points out that there are two ways for air to enter a pulmonary vein during a percutaneous lung biopsy. The first is for atmospheric air to enter a pulmonary vein crossed by the biopsy needle. This can be avoided by having patients hold their breath whenever the stylet is uncovered. The second way is that a needle traversing a bronchus and a pulmonary vein can establish a tract between the two that may remain patent after the needle is removed, especially if the structures are rigid, such as in patients with extensive consolidation, abscess, or pleural disease.[23]

Another concern is the possibility of seeding malignant cells along the needle tract of an aspiration biopsy. As of 1985, however, there were only four known cases of tumor spread along "fine" needle tracts.[24] Greene recommends the use of coaxial introducing needles to reduce this almost theoretic risk.[10]

In summary, then, thin-needle aspiration biopsy of the lung is safe. The major complication is pneumothorax, and only about 10% of all patients require any kind of therapy following the biopsy.

Results

The results of eight series of transthoracic needle aspiration biopsies are shown in Table 2.

Probably the most important aspect of the percutaneous lung biopsy is its sensitivity for malignancy. Without sensitivities consistently near 100%, the specter of a missed malignant neoplasm looms large. The possibility that one will lose the chance to cure a patient of lung cancer is too great a risk for most clinicians and patients to take.

Various researchers have proffered suggestions on how best to avoid "false-negative" results. A common recommendation is the use of CT, particularly for large lesions, to decrease the chance of taking a biopsy of necrotic tissue in malignant tumors. CT can help a radiologist obtain material from the usually viable peripheral zone of a mass.[16,19,25,26] Westcott, moreover, cautions against doing a percutaneous lung biopsy in any patient with atelectasis or lobar consolidation,[11] for both he and others[17] have obtained spuriously negative results in cases where tissue distal to an obstructing bronchogenic carcinoma was taken instead of tumor. Both

TABLE 2.—*Results of Thin-Needle Aspiration Lung Biopsy*

Source	N*	Diagnostic Yield, %†	Sensitivity, %	Specificity, %	PV+‡	PV−§
Westcott, 1980[11]	400	100	98	96	99	95
Greene et al, 1985[12]	150	97	97	100	100	87
Khouri et al, 1985[17]	650	77	95	96	99	82
Lalli et al, 1978[18]	1,296	86	85	99	99	64
Berquist et al, 1980[19]	430	82	100	100	100	100
Landman et al, 1975[20]	80	100	89	100	100	88
Stevens & Jackman, 1984[21]	447	83	92	98	99	78
Dahlgren & Lind, 1972[25]	145	92	100	96	99	100

*N = the total number of biopsies done.
†The diagnostic yield refers to the number of biopsies judged "benign" or "malignant" versus the number done.
‡PV+ = predictive value of positive result.
§PV− = predictive value of negative result.

Westcott and Greene and co-workers advocate the use of histologic specimens to increase the chance of obtaining a specific, and therefore more reliable, benign diagnosis.[11,12] In addition, several investigators, such as Gobien and associates, encourage repeating an aspiration biopsy if the initial attempt yields insufficent tissue for a specific pathologic assessment of benignity or malignancy.[26]

These measures notwithstanding, there will probably always be a risk of a missed malignant neoplasm associated with a percutaneous lung biopsy.

Competitors and Complements

The Initial Workup

History, physical, and laboratory evaluation. Any diagnostic workup begins with a history, and that of a solitary pulmonary nodule is no exception. Age is a critical factor in the risk of malignant solitary nodules: primary lung cancers are rare in persons younger than 30 years.[3,5,27] A smoking history increases the risk of malignancy.[3] A positive purified-protein-derivative test or a history of exposure to tuberculosis may support a benign diagnosis,[27] but neither excludes a malignant neoplasm. Indeed, the presence of active tuberculosis may increase the risk of concomitant malignancy: Gopalakrishnan and colleagues found a 90-fold increase in the incidence of lung cancer among their patients with tuberculosis compared with the general population.[28]

A patient who is symptomatic from a pulmonary nodule—the most common complaint is hemoptysis—is more likely to have a malignant lesion, as 80% to 85% of pulmonary masses causing hemoptysis are malignant.[3] It is rare, however, for a solitary pulmonary nodule—benign or malignant—to cause symptoms, and thus the lack of hemoptysis does not support a benign diagnosis.[27]

A history of prior malignancy increases the likelihood of a solitary pulmonary nodule being metastatic, but it does not exclude the possibility of a new primary or benign disease.[3,5] In Adkins and co-workers' series of 31 patients with a history of presumably cured cancers and a single pulmonary mass who underwent thoracotomy, only 22 patients had metastatic disease; 2 had new primary cancers, and 7 had benign disease.[29]

The physical examination is rarely helpful in assessing a solitary pulmonary mass except as it may reveal the source of metastatic disease. Similarly, laboratory tests in the workup of a solitary lung mass are most helpful if they uncover sources of metastases. Lawhorne and associates recommend measurements such as a hematocrit, liver function tests, analysis of urine, and a guaiac test of stool to help rule out extrathoracic primary lesions.[30]

Radiologic Assessment

Chest roentgenogram. The solitary pulmonary nodule, by definition, is a roentgenographic finding, and much information about the mass can be gleaned from the chest radiograph. Among the key elements in the radiographic assessment of a solitary lung mass are the presence of calcification, growth rate, contour, and size. Only the first two are reliable enough to exclude the presence of malignancy.[3,27]

Certain patterns of calcification in a nodule are reliable indicators of benignity. "Benign" patterns include laminated or concentric calcification (characteristic of granulomas), a central calcified nidus, "popcorn" calcification (typical of hamartomas), or homogeneous calcification.[3,27] These patterns are helpful, for calcification on a chest radiograph does not absolutely exclude malignancy. Generally, if a malignant nodule is calcified, it will show an eccentric pattern. Even with a "benign" pattern, however, most authors recommend follow-up chest radiographs at three to six months and yearly thereafter.[3,27]

The absence of growth of a solitary pulmonary nodule can also be used to establish benignity. If a lesion shows no change over the course of two years, it is benign. Yearly follow-up chest radiographs are still recommended, however.[3,27]

The contour of a pulmonary nodule can be suggestive of malignancy or benignity. Generally, an irregular contour, a spiculated border ("corona radiata"), and ill-defined margins argue for malignancy; smooth edges support a benign diagnosis.[3,27,31] A lobulated or umbilicated contour is usually a result of differential growth rates at the periphery of a lesion and is characteristic of malignancy. Lobulations may also be seen, however, in patients with tuberculosis or hamartomas.[27] Thus, the contour and margin of a lesion should not be used in isolation to assess its malignancy.

Likewise, the size of a lesion may be suggestive—but not diagnostic—of malignancy. Lesions greater than 3.5 cm in diameter are usually malignant.[3,31] Small nodules tend to be benign, but once a lesion has passed the radiographic threshold of about 1 cm, there is too much overlap between malignant and benign lesions to warrant delaying surgical excision or another diagnostic procedure on the basis of size.[27]

Tomography and CT. In the past, conventional tomography has been used both to increase the detection of calcification in a lung nodule and to visualize any additional nod-

ules.[32] In recent years, however, more researchers have been focusing their attention on CT.

In the past decade, the role of CT in the workup of solitary pulmonary nodules has been continually changing. A 1978 study by Raptopoulos and associates of solitary pulmonary nodules assessed with CT was promising in detecting calcification in benign lesions.[33] Subsequent attempts to confirm the usefulness of CT in this role met with mixed success, however.[27] The major pitfalls are well outlined by Godwin[27] and include the technical differences among scanner models and even among different machines of the same models.

Thin-section CT and improvements in standardization have helped solve some of these problems. The development of a reference "phantom" has finally allowed studies of CT densitometry independent of variations among scanners.[14,31] The initial results are promising and indicate that in small nodules (<3 cm), CT can greatly enhance the ability to establish a benign diagnosis.[31] The criteria for benignity currently used are high attenuation values—exceeding critical levels and distributed throughout the CT section through the center of the lesion—and a well-defined edge.[14] How great a role CT will have in assessing solitary pulmonary nodules remains to be seen. At the moment, it promises the ability to firmly and objectively establish a benign diagnosis, but only in a select group of nodules: small lesions with calcification and smooth margins.

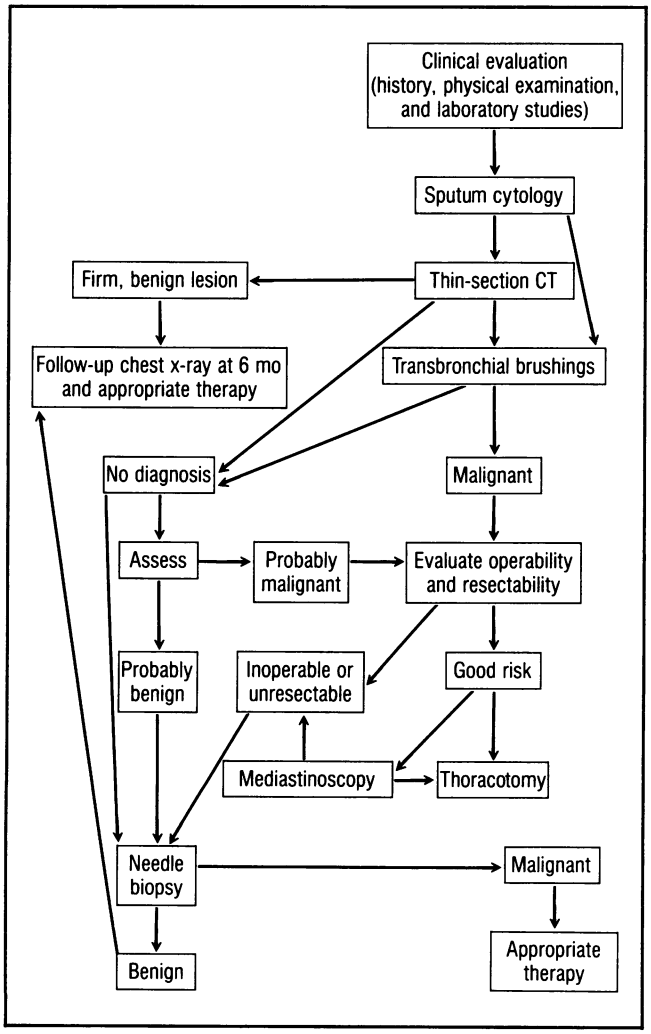

Figure 1.—The algorithm shows the steps to be taken when evaluating a patient with a solitary pulmonary nodule. CT = computed tomography

Other radiologic evaluations. A recurring question in the workup of solitary pulmonary nodules is what effort should be made to completely rule out extrathoracic cancers. In the absence of a histologic diagnosis, is a preoperative upper gastrointestinal series, barium enema, or an intravenous pyelogram called for? Lawhorne and colleagues reviewed the literature and found that less than 2% of solitary pulmonary nodules represent metastatic disease from occult cancer sites.[30] Thus, they concluded that these additional radiologic examinations are not indicated.

Sputum Cytology

The findings of sputum cytology are rarely diagnostic in the evaluation of a solitary pulmonary nodule.[27] False-positive tests are relatively common in the presence of inflammatory disease.[25] Moreover, a negative study is of questionable value: Dahlgren and Lind reported a test sensitivity of only 40% among 125 patients assessed with sputum cytology before thoracotomy for a single lung nodule.[25] When three consecutive sputum specimens were collected, however, the sensitivity for malignancy rose to 80%. The flaws of sputum cytology notwithstanding, its primary value is as a screening tool, for it is one of the cheapest and least harmful methods of detecting lung carcinoma.

Transbronchial Brush Biopsy

Transbronchial brushing is a noninvasive procedure with almost no complications. Generally, transbronchial brushings will be diagnostic more often than sputum cytologies but not as often as transthoracic needle aspiration biopsies.[10,20,27]

Landman and co-workers reported a test sensitivity of 72% overall among 100 patients with transbronchial brush biopsies.[20] Their success was almost entirely with centrally located bronchogenic carcinomas, of which transbronchial brushings detected 80%. Their transbronchial examinations were uniformly negative for malignant neoplasms other than bronchogenic carcinoma. Walls and associates similarly reported the complete failure to diagnose Pancoast tumors with bronchoscopy and washings,[22] compared with a test sensitivity of 100% for transthoracic needle aspiration biopsies of Pancoast tumors.

Transbronchial brush biopsy is most useful for diagnosing centrally located bronchogenic carcinomas.[20] The test sensitivity of percutaneous lung biopsy, however, is much greater than that of transbronchial brushings if a lesion is less than 2 cm in diameter; peripherally located; arises in the upper lobes; and does not arise in bronchial epithelium, such as in metastatic disease.

The Role of Percutaneous Lung Biopsy

The Workup of Undiagnosed Solitary Pulmonary Nodules

Researchers have yet to reach a consensus regarding the role of transthoracic needle aspiration biopsy in the assessment of the solitary pulmonary nodule. The algorithm shown in Figure 1 attempts to reconcile some of the evidence known to date.

The following points regarding the algorithm should be kept in mind (Figure 1):

- CT will probably not be helpful if the lesion is larger than 3 cm in diameter or has an irregular border.[31]

- Transbronchial brushings will contribute little if the lesion is less than 2 cm in diameter, peripheral, in the upper lobes, or likely to be metastatic.[20]
- In inoperable or unresectable cases, a histologic diagnosis offers both a confirmation of malignant disease and necessary data for irradiation or chemotherapy.
- The leap from no preliminary diagnosis to a needle biopsy remains a controversial step. Workers in the field have varying opinions, ranging from the thinking that percutaneous lung biopsy is "not appropriate for operable patients with strong evidence of malignant lesions"[27] to the claim of Lalli and co-workers that "a clear indication" for transthoracic needle aspiration biopsy is "the presence of a nodular lesion anywhere in the lung of a surgical candidate suspected of having a bronchogenic carcinoma," and that, in such cases, a thoracotomy is "indefensible."[18]

The lack of consensus around the last step represents a fundamental weakness of algorithms—that medicine cannot be practiced by flow charts.

Other Indications for Transthoracic Needle Aspiration Biopsy of a Solitary Lung Mass

A patient with a solitary pulmonary mass thought to be probable metastatic disease. In a patient with suspected cerebral or symptomatic bony metastases, a diagnosis of bronchogenic carcinoma is considered sufficient to begin radiation treatment to these lesions.[8,32]

A patient with a solitary mass and a known extrathoracic primary cancer. If CT shows that in such cases a lung nodule truly is solitary, then a needle aspiration biopsy is called for to rule in or rule out metastatic disease. Granted, the study of Adkins and associates showed an increased survival among such patients with extrathoracic cancer undergoing thoracotomy whether their solitary pulmonary nodule represented a new primary or metastatic disease.[29] Thus, some would argue that these patients do not benefit from a percutaneous lung biopsy but should instead proceed directly to thoracotomy. Stitik points out, however, that a diagnosis of metastatic disease is helpful,[8] for it allows the physician to intensify a search for other metastases before subjecting the patient to a surgical procedure.

A patient who refuses surgical treatment for a solitary pulmonary mass probably due to cancer. In the case of a resectable lesion in an operable patient who refuses an operation, a histologic or cytologic examination is needed for appropriate irradiation or chemotherapy. Moreover, a diagnosis of malignancy may spur such a patient to a surgical excision.[8]

A patient with a superior sulcus (Pancoast) tumor. Hilaris and colleagues are among the investigators who have shown that preoperative radiation therapy for Pancoast tumors improves patients' survival.[34] Particularly considering the low test sensitivity of sputum cytology and transbronchial brush biopsy in the diagnosis of apical lung cancer,[22] transthoracic needle aspiration biopsy is helpful in such cases.

Undiagnosed lung lesions in the immunosuppressed. In immunosuppressed patients with a solitary pulmonary nodule, opportunistic organisms or common bacterial pathogens can be specifically identified by a needle aspiration biopsy.[10] Not only does a swift diagnosis hasten vital therapy, but also these patients are often debilitated and may be only marginally operable.

Conclusion

It can be seen, then, that transthoracic needle aspiration biopsy does have a role in the workup of a solitary pulmonary nodule. Clinicians vary greatly, however, in how they limit that role. In some cases, such as an inoperable patient with a likely malignant lesion and normal results of a transbronchial brush biopsy, authors are in agreement that percutaneous lung biopsy is called for. Over a similar lesion in an operable patient, however, there is great dispute.

Surely the role of needle aspiration biopsy will continue to evolve. Standardization and further refinement of CT technology promises to eliminate some of the demand for a cytologic diagnosis by providing firm benign assessments. Improvements in cytology may increase the now low sensitivity of sputum cytology and transbronchial brush biopsies, thereby eliminating the need for an aspiration biopsy. On the other hand, improvements in cytology and other fields may increase the use of the percutaneous lung biopsy. Advances in cytology have allowed thin-needle aspiration, a much safer procedure than cutting needle biopsies. The promise that percutaneous lung biopsy offers is of a safe, relatively inexpensive, and increasingly reliable diagnosis. Some authors argue that even in an operable candidate, a malignant diagnosis has value insofar as it speeds a patient to surgery.[8,35]

But all clinicians can see the merit in a reliable, preoperative benign diagnosis. By preventing an unnecessary thoracotomy, morbidity and mortality are considerably reduced. Moreover, now that percutaneous lung biopsies may be safely done on an outpatient basis, the monetary savings are considerable: Stevens and Jackman estimated that the cost of a needle aspiration biopsy of a solitary lung nodule done on an outpatient basis was $382, whereas the bill for a diagnostic thoracotomy with a five-day hospital stay came to $9,000.[21] Other authors report great savings even in inpatient settings.[34] These savings may well drive institutions to change their patterns of care, and the use of such techniques as needle aspiration biopsy depends a great deal on institutional policy and referral patterns.[8]

Ultimately, however, the decision to use and to trust the findings of a transthoracic needle biopsy of a solitary lung mass is not an institutional one, but a personal one, made by the clinician, the radiologist, and the patient. Their ability to tolerate uncertainty will determine that decision. No flurry of studies or statistics, ledgers, or litigation will change the approach to the "solitary pulmonary nodule" from being an individualized decision, made anew with every case.

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Microbial Keratitis From Contact Lenses

DO YOU KNOW how many Americans are out there wearing contact lenses? It's about 8% to 10% of the population of this country. That's over 20 million Americans. I mean, if only .001% of those patients were getting this complication, that's thousands of people at risk of getting a corneal infection as a principal complication of contact lens wear.

In the literature, thousands of cases of corneal infections in contact lens wearers have now been reported. In Houston, the leading cause of corneal infection is contact lens wear.

What about the contact lens type? Hard lenses, daily wear, extended wear, and therapeutic lenses are the four choices we've got. Almost all cases that have now been reported are in soft contact lenses. The type of lens—the type of plastic—really seems to be a principal risk factor.

I did a literature survey and found 500 culture-proved cases and mapped those out with regard to the type of lens the patient was wearing when a corneal infection, culture-proved by corneal scrapings, was reported. Three fourths were wearing soft lenses, two thirds were wearing soft lenses for cosmetic reasons—they had 20/20 vision. Over a third were wearing extended wear lenses.

I've come up with some ways to prevent the problem—and unfortunately, they're not very innovative. They are things you're probably already doing and recommending, but let me just reiterate:

- Wash hands. I think, obviously, all eye care persons should wash their hands before manipulating any patient's eyes and before any eye examination or contact lens insertion. Patients should wash their hands before each contact lens manipulation as well.
- Remove that lens regularly. The patient should remove daily wear lenses in a daily wear schedule and clean and disinfect those lenses routinely. Obviously, here's a problem with patient compliance in a large number of cases.
- Use clean accessories. About a quarter of the cases have been traced back directly to contaminating organisms in the contact lens case and solution. Examine the lenses for spoilage at each eye checkup. And then lastly, reinstruct the patients periodically. This may be *the* most important and the best way we have of preventing this problem in our patients.

—KIRK R. WILHELMUS, MD

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